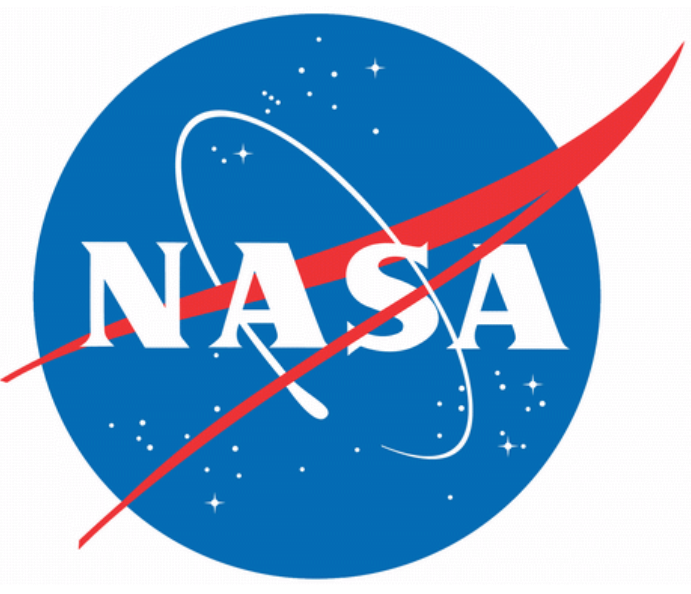




Analysis of Water and Energy Budgets and Trends Using the NLDAS Monthly Data Sets

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Introduction

The North American Land Data Assimilation System (NLDAS) is a collaborative project between NASA GSFC, NOAA, Princeton University, and the University of Washington. NLDAS has created surface meteorological forcing data sets using the best-available observations and reanalyses. The forcing data sets are used to drive four separate land-surface models (LSMs), Mosaic, Noah, VIC, and SAC, to produce data sets of soil moisture, snow, runoff, and surface fluxes.

NLDAS **hourly** data, accessible from the NASA GES DISC Hydrology Data Holdings Portal, <http://disc.sci.gsfc.nasa.gov/hydrology/data-holdings>, are widely used by various user communities in modeling, research, and applications, such as drought and flood monitoring, watershed and water quality management, and case studies of extreme events. More information is available at <http://ldas.gsfc.nasa.gov/>.

To further facilitate analysis of water and energy budgets and trends, NLDAS **monthly** data sets have been recently released by NASA GES DISC.

NLDAS Data Characteristics

Table 1. NLDAS Data Basic Characteristics

Content	Water and energy budget data, forcing data, soil moisture/temperature data
Spatial coverage	Conterminous U.S., parts of southern Canada and northern Mexico (25N ~ 53N, 125W ~ 67W)
Spatial resolution	0.125° X 0.125°
Temporal coverage	Phase-1: Aug. 1, 1996 - Dec. 31, 2007; Phase-2: Jan. 1, 1979 – present
Temporal resolution	Hourly and Monthly (NEW AND JUST RELEASED)
Forcing	Multiple data sets derived from satellite measurements, radar estimation, precipitation gauges, and atmospheric analyses
Land surface models	Mosaic, Noah, SAC, VIC
Output format	GRIdded Binary (GRIB)
Elevation definition	GTOPO 30
Vegetation definition	University of Maryland, 1 km

How are the NLDAS monthly data generated?

- NLDAS monthly data are generated from their corresponding hourly data by monthly accumulation for some water-related variables and monthly average for the others.
- Time period for each month is from 00Z at the start of the month to 23:59Z at the end of the month, except for the first month (Jan. 1979). The period for Jan. 1979 is dependent on data set starting date and time (more details available in NLDAS README documents).
- NLDAS-1 Monthly Forcing Data Set: Monthly accumulation for precipitation variables (ACPCPsfc, APCPsfc, PEDASsfc, and PRDARSfc) and monthly average for others.
Two new variables for NLDAS-1 monthly forcing data set:
 - Convective precipitation monthly total (CONVAPCPsfc)
 - Shortwave radiation flux downwards (surface) blended from EDAS and GOES-UMD Pinker (RSWRFsfc)
- NLDAS-2 Monthly Primary Forcing Data Set: Monthly accumulation for total precipitation, convective precipitation, and potential evaporation, and monthly average for other variables.
- NLDAS-2 Monthly Secondary Forcing Data Set: Monthly accumulation for precipitation and convective precipitation and monthly average for others.
- NLDAS-2 Monthly Mosaic and Noah Model Data Sets: Monthly accumulation for rainfall, snowfall, subsurface runoff, surface runoff, total evapotranspiration, and snow melt, and monthly average for others.

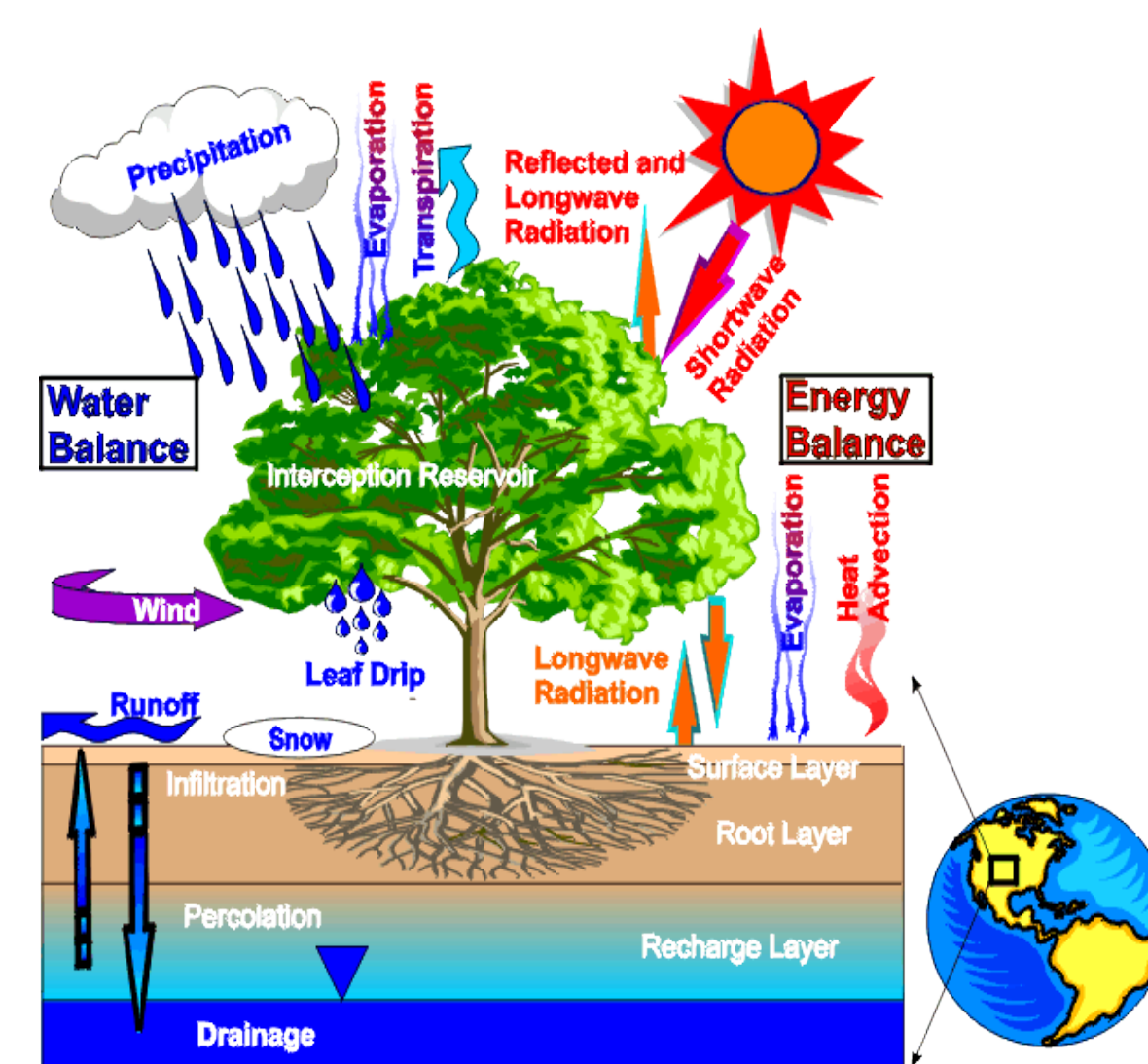
More detailed information is available in the NLDAS README documents, located at: <http://disc.sci.gsfc.nasa.gov/hydrology/documentation>.

NLDAS Data Access and Services

All NLDAS data sets available from the NASA GES DISC can be accessed from the Hydrology Data Holdings Portal, <http://disc.sci.gsfc.nasa.gov/hydrology/data-holdings>, via the following access methods:

- Direct ftp: simple, fast, and navigation
 - Mirador: keyword search, navigation, subsetting, and format conversion
 - GrADS Data Server (GDS): data aggregation and retrieving data in ASCII
 - Giovanni: visualization, analysis, and data download
 - Simple Subset Wizard (SSW): Keyword search, subsetting, and format conversion
- Both Mirador and SSW provide parameter and spatial subsetting and format conversion (GRIB to NetCDF), currently for all hourly data sets and, in the future, for all monthly data.

NLDAS Water and Energy Variables



Water Balance

$$P = Q + E + \Delta S$$

P – Precipitation

Q – Runoff

E – Evapotranspiration

ΔS – Water Storage Change

Energy Balance

$$Rn - G = Le + H$$

Rn – Net Radiation

G – Ground Heat flux

Le – Latent heat flux

H – Sensible heat flux

Figure 1. A simplified schematic diagram showing the energy and water balances studied by the LDAS Project. More detailed diagrams and references for NLDAS-2 models (Mosaic, Noah, VIC, and SAC) are at: <http://ldas.gsfc.nasa.gov/nldas/NLDAS2model.php>

Table 2. Major Variables of NLDAS Forcing Data Sets and Model Outputs

Energy Balance	Water Balance	Surface and subsurface State
Longwave radiation flux downwards	Precipitation	Average layer soil moisture
Shortwave radiation flux downwards	Rainfall (unfrozen precipitation)	Average layer soil temperature
Ground heat flux	Snowfall (frozen precipitation)	Humidity
Latent heat flux	Runoff (surface and subsurface)	Temperature
Sensible heat flux	Average layer soil moisture	Snow cover
Snow phase-change heat flux	Potential evaporation	Snow depth
Snow melt	Total evapotranspiration	Albedo
	Snow melt	Leaf area index
	Accumulated snow water-equivalent	Vegetation

NLDAS provides more than 33 years of data for these major water balance and energy balance variables, and the data can be used for studying water and energy budgets and trends.

For the complete list of NLDAS variables, please go to NLDAS README Documents.



Hydrology Portal



LDAS Portal

Summary

- NLDAS **hourly** data, accessible from NASA GES DISC, are widely used by various user communities in modeling, research, and applications, such as drought and flood monitoring, watershed and water quality management, and case studies of extreme events.
- To further facilitate analysis of water and energy budgets and trends, NLDAS **monthly** data products have been recently released by NASA GES DISC.
- NLDAS monthly data are generated from their corresponding hourly data by monthly accumulation for some water-related variables and monthly average for others.
- NLDAS provides major **water balance and energy balance variables** and can be used for studying water and energy budgets and trends.
- NLDAS **monthly Climatology data** will be released in Jan. 2013 and will facilitate analysis of trends and anomalies.

NLDAS Water & Energy Budgets and Trends

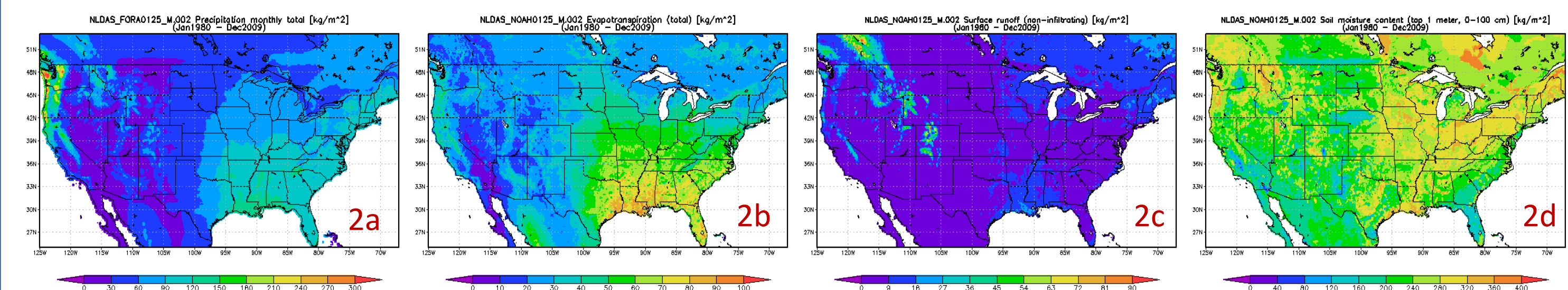


Figure 2. Long-term mean (Jan. 1980 – Dec. 2009), averaged from NLDAS-2 **FORA** and **Noah** monthly data, showing spatial distributions of these water balance variables of precipitation (2a), evapotranspiration (2b), surface runoff (2c), and top 1 meter soil moisture content (2d).

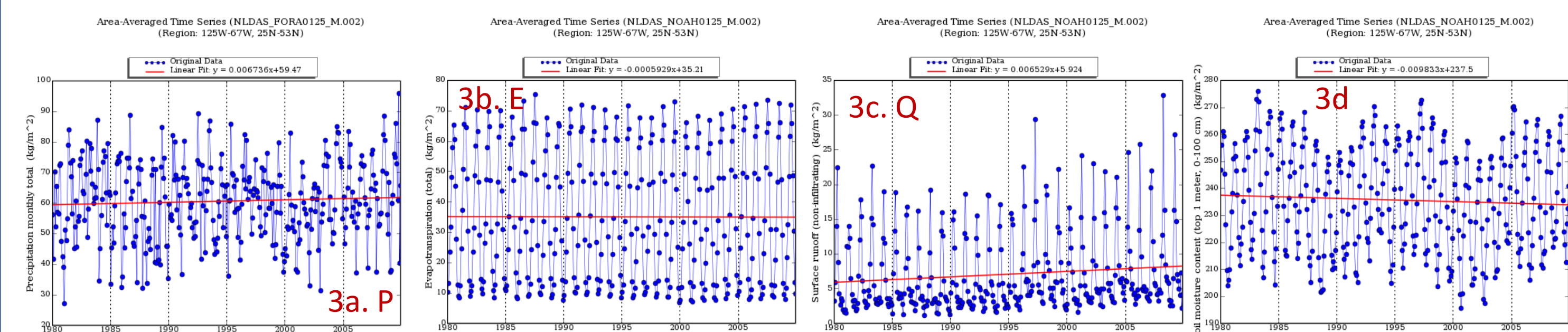


Figure 3. Time series (Jan. 1980 - Dec. 2009) of Water Balance Variables from NLDAS-2 **FORA** and **Noah** monthly data, averaged over the entire NLDAS domain. The 30-year NLDAS time series of precipitation (3a) and surface runoff (3c) show a slight up trend, but total evapotranspiration (3b) and the top 1 meter soil moisture (3d) show a slight down trend.

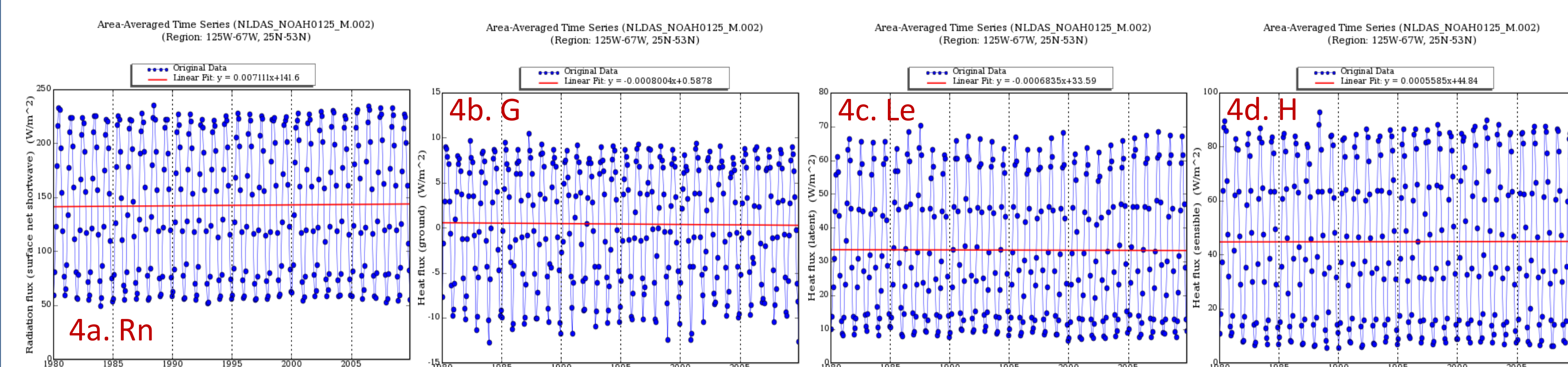


Figure 4. Time series (Jan. 1980 - Dec. 2009) of Energy Balance variables from NLDAS-2 **Noah** monthly data, averaged over the entire NLDAS region. The 30-year of time series of net shortwave radiation flux (4a) and sensible heat flux (4d) show a slight up trend, but ground heat flux (4b) and latent heat flux (4c) show a slight up trend.

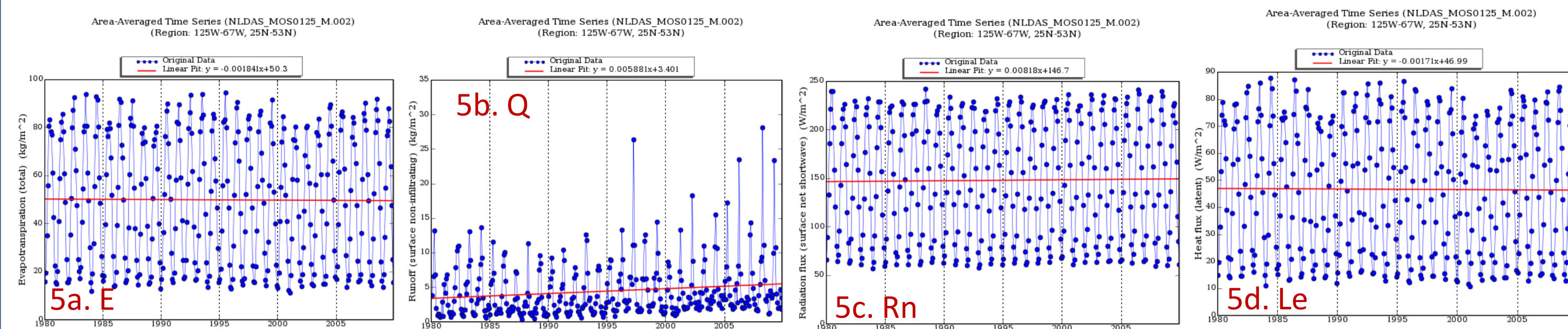


Figure 5. Time series (Jan. 1980 – Dec. 2009) of Water Balance and Energy Balance variables from NLDAS-2 **Mosaic** monthly data, averaged over the entire NLDAS region. Similar to the results from Noah monthly data, the 30-year time series of evapotranspiration (5a) and latent heat flux (5d) show a slight down trend, but surface runoff (5b) and net shortwave radiation flux (5c) show a slight up trend.

All plots in Figures 2, 3, 4, and 5 are generated by Giovanni NLDAS Monthly Portal.

Upcoming New Data and Services

New Data Sets (expected release date):

- NLDAS-1 & 2 Monthly climatology (Jan. 2013)
- NLDAS-2 hourly and monthly SAC model data (Spring 2013)
- NLDAS-2 hourly and monthly VIC model data (Summer 2013)

New Data Services

(expected release date early 2013)

- Services for NLDAS monthly data:
 - Parameter and spatial subsetting
 - GRIB to NetCDF Conversion
 - Subsetting + NetCDF conversion
- Giovanni Portal for NLDAS monthly climatology.